

Factors associated with failure in ventilatory weaning of children undergone pediatric cardiac surgery

Fatores associados ao insucesso no desmame ventilatório de crianças submetidas a cirurgia cardíaca pediátrica

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Abstract

Objective: To assess factors associated with unsuccessful ventilatory weaning of children submitted to the surgical correction of congenital heart diseases.

Methods: This is a cohort study of 29 children. Heart diseases were divided into cyanotic (nine children) and acyanotic (20 children). We studied children from 0 to 5 years old who underwent heart surgery with invasive mechanical ventilation.

Results: The unsuccessful group presented with a lower SpO₂ level and higher values during days on invasive mechanical ventilation and in the FiO₂ level when compared to the successful group (P < 0.05). Four children (14%) were unsuccessfully weaned with the necessary to re-establish ventilation within 48 hours after extubation.

Conclusion: The number of days of invasive mechanical ventilation, reduced SpO₂ and elevated FiO₂ levels were the main factors associated with unsuccessful extubation in this group of patients.

Descriptors: Cardiac surgical procedures. Heart defects, congenital/surgery. Respiration, artificial. Ventilator weaning/adverse effects.

Resumo

Objetivo: Verificar os fatores associados ao insucesso no desmame de crianças submetidas a correção cirúrgica de cardiopatias congênitas.

Métodos: Estudo de coorte. A amostra foi composta de 29 crianças. As cardiopatias foram divididas em cianóticas (nove crianças) e acianóticas (20 crianças). Foram estudadas crianças de 0 a 5 anos, submetidas a cirurgia cardíaca com permanência em ventilação mecânica invasiva.

Resultados: O grupo insucesso apresentou valor menor na SpO₂ e valores maiores nos dias de permanência em VMI e na FiO₂ quando comparados ao grupo sucesso (P < 0,05). Observou-se que quatro (14%) crianças tiveram insucesso no desmame, sendo necessário retornar a prótese ventilatória antes de 48 horas após a extubação.

Conclusão: Os dias de VMI, a SpO₂ reduzida e a FiO₂ elevada foram os principais fatores associados à falha na extubação neste grupo de pacientes.

Descritores: Procedimentos cirúrgicos cardíacos. Cardiopatias congênitas/cirurgia. Respiração artificial. Desmame do respirador/efeitos adversos.

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INTRODUCTION

Congenital diseases are the main cause of mortality in newborn infants. They can be classified in acyanotic and cyanotic congenital heart diseases. Acyanotic congenital heart diseases occur because of a left-to-right shunt, due to an obstruction in the left or right heart chambers or due to congenital anomalies of the coronary arteries. In cyanotic congenital heart diseases, there is a right-to-left shunt because of obstructive lesions of the right heart chambers associated with an intracavity communication or the heart disease leads to desaturation of systemic blood due to the mixture of the systemic circulation with the pulmonary circulation or due to discordance in the ventriculo-arterial connection [1-3].

In Brazil, the prevalence of congenital heart diseases is approximately 5.5:1000 live births according to Guitti [4], with most of these infants not surviving until adulthood without undergoing a surgical intervention.

The indication for surgical correction in most congenital heart diseases is nowadays routine and almost systematic soon after diagnosis. The postoperative management of these patients requires assistance in the intensive care unit (ICU) with invasive mechanical ventilation (IMV) in the immediate postoperative period [2,3,5].

Children that are submitted to heart surgery are extubated soon after the end of or after a reduction in the effects of anesthesia, as prolonged use can cause pneumonia, hypertrophy of the diaphragm and increase the morbidity and mortality rates. Factors such as the necessity of a cardiopulmonary bypass (CPB) may lead to prolonged IMV thus interfering in the weaning of this child [6-8].

Sudden or even inadequate extubation of patients that do not present with adequate conditions may result in a clinical imbalance and the necessity of re-intubation, which adversely impacts on the clinical evolution of the patient [6,9-11]. The clinical conditions for successful extubation include: adequate respiratory frequency, the absence of the utilization of accessory musculature, the absence of vacillation of the wings of the nose, hemodynamic stability and the absence of convulsive fits [4]. Even so, the selection of the most appropriate time for extubation is one of the most difficult decisions, as there are several publications that identify risk factors of unsuccessful weaning with the criteria varying between the studies; there are no exact protocols in the literature with specific validated data for this group of patients [12-14].

Hence, this study aimed at studying factors associated to unsuccessful weaning from IMV in children submitted to the surgical correction of congenital heart diseases.

METHODS

This work is a study of a cohort of patients hospitalized in the heart unit of the ICU of the Santo Antônio Children's Hospital (HCSA) in the immediate postoperative period of surgical correction of congenital heart diseases.

The project was submitted to the Research Ethics Committees of Santa Casa and the Methodist University IPA for approval (protocol number 1228-06 with complementary report number 076-06). Written consent was obtained from the guardians of the patients.

Study population

In the period from November 2006 to July 2007 patients, of both genders with ages between 0 and 5 years old and hospitalized in the ICU of HCSA, were included in the study during the immediate postoperative period of correction surgery for congenital heart disease if they required IMV.

The initial sample consisted of 32 patients; there was a loss of 3 patients who died while still on IMV. Thus the final sample was composed of 29 children.

The exclusion criteria of the study included: patients with neurological sequelae, patients with acute respiratory distress syndrome (ARDS), the occurrence of cardiorespiratory arrest in the trans-operative period, children with sepsis and permanence of the sternum open.

Measurements and instruments

The patients were observed twice daily at 11:00 a.m. and 6:00 p.m. until 48 hours after extubation to verify and register the parameters of IMV. The variables were: inspiratory pressure (IP), positive end expiratory pressure (PEEP), fraction of inspired oxygen (FiO_2), air flow volume (AFV), volume-minute (VM), heart rate (HR), respiratory rate (RR), saturation of peripheral oxygen (SpO_2), gasometric values, underlying disease, type of heart disease (acyanotic or cyanotic), as well as physiotherapeutic assistance provided.

The IMV apparatuses utilized by the patients were SECHRIST (model IV-100 B, Model IV-200 and Millennium) and Servo Ventilator 300. The pulse oximeter and heart monitoring apparatuses utilized were Agilent V24, Marquette Hellige – Eagle 1000, Phillips Anesthesia V24 and Hewlett Packard Model 54S.

Ventilometry was performed using an analogue apparatus (Ohmeda); which was connected to the exhalation valve of the mechanical ventilator during one minute, thereby obtaining a measurement of the VM. The data were collected with the patient in the supine position. The variables observed by ventilometry were: AFV, VM and RR with AFV being calculated by the ratio VM:RR.

Blood was drawn for arterial gasometry by nursing staff using a syringe with heparin under anaerobic conditions,

as is the routine of the ICU. Blood sampling was normally performed once daily or according to the general state of the patient; the radial, femoral, brachial or ulnar arteries were usually punctured for this purpose.

Statistical analysis

The data were input in a Microsoft® Excel 2000 database and analysed using the Statistical Package for the Social Sciences (SPSS), version 13.0. Qualitative data are expressed as numbers (% of all the patients).

The analysis of quantitative data with normal distributions was achieved using the ANOVA test. Analysis of continuous data without a normal distribution was by the Mann-Whitney ‘U’ test. The qualitative data were analyzed by the Chi-squared test, employing, when necessary, Yates correction or Fisher’s exact test.

The level of significance was set at a *P*-value < 0.05. A sample size of 94 children was calculated considering a confidence level of 95% and an error margin of 5%. This study is ongoing, and so it presents the analysis of 29 children studied in the period from January to September 2007.

RESULTS

The patients were classified as successful (Success Group – SG) and unsuccessful (Unsuccessful Group – UG) weaning. The SG corresponded to those patients who remained without the necessity of ventilatory assistance for a period of 48 hours after extubation and the UG was defined as the group of patients who required re-intubation within 48 hours.

Table 1 shows the general characteristics of the patients, with 17 (58.6%) being boys. The congenital heart diseases were subdivided in cyanotic, nine (31%) children and acyanotic 20 (69%) children. During the stay on IMV, of the total of 29 children, only 15 (51.7%) received respiratory physiotherapy requested by the medical team.

Twenty-five (86%) children were successfully weaned from ventilatory assistance and four (14%) were not with the necessity of re-intubation within 48 hours.

The variables used to verify factors associated to extubation success or failure were analyzed individually in respect to the sample distribution.

Table 2 shows the demographic and clinical data of the children in the postoperative period. A statistically significant difference was found in relation to the length of stay on IMV (*P* = 0.005), with the UG remaining for a longer period. The comparison of FiO₂ presented a significant difference between the groups (*P* = 0.0028) as the UG required higher values of FiO₂. The UG presented with the SpO₂ significantly lower than the SG (*P* = 0.004). Significant

differences between the groups were not identified for the other parameters (*P* > 0.05).

Table 3 demonstrates the gasometric values for the children in the postoperative period after surgeries for congenital diseases. Statistical differences were not found for the gasometric parameters between the groups (*P* > 0.05).

Table 1. General characteristics of the patients

	Number	Percentage
Gender		
Male	17	58.60%
Female	12	41.40%
Weaning		
Successful	25	86%
Unsuccessful	4	14%
Heart disease (n)		
Cyanotic	9	31%
Acyanotic	20	69%
Physiotherapy		
Yes	15	51.70%
No	14	48.30%

Chi-squared test and Fischer exact test

Table 2. Demographic and clinical variables of children in the postoperative period of the surgical correction of congenital heart diseases

	SG (n=25) mean ± SD	UG (n=4) mean ± SD	P
weight (kg)	6.18 ± 2.90	5.02 ± 2.65	0.459
Age (months)	9.96 ± 11.91	3.83 ± 3.60	0.321
Surgery time (h)	3.11 ± 0.99	2.54 ± 1.53	0.326
Days on IMV	3.43 ± 4.52	13.50 ± 8.66	0.005*
CPB (min)	56.80 ± 47.57	29.37 ± 57.09	0.305
HR (bpm)	132.52 ± 20.89	136.75 ± 15.90	0.703
RR (irpm)	14.0 ± 4.19	16.0 ± 6.60	0.512
SpO ₂ (%)	93.44 ± 8.03	70.0 ± 15.05	0.004*
VM (l)	9.27 ± 3.17	11.24 ± 0.96	0.137
AFV (mL)	689.0 ± 358	774.0 ± 332	0.662
IP (cmH ₂ O)	19.80 ± 4.05	23.0 ± 4.76	0.162
PEEP (cmH ₂ O)	4.48 ± 0.91	4.75 ± 1.25	0.606
FiO ₂ (%)	34.72 ± 9.59	52.75 ± 33.71	0.028*

*ANOVA test = analysis of variance. *P < 0.05 SD = standard deviation; CPB = cardiopulmonary bypass; IMV = invasive mechanical ventilation; IP = inspiratory pressure; PEEP = positive end expiratory pressure; VM = volume-minute; SG = successful group; UG = unsuccessful group*

Table 3. Gasometric values of children in the postoperative period of the surgical correction of congenital heart diseases

	SG (n=25)	UG (n=4)	P
	mean ± SD	mean ± SD	
pH	7.36 ± 0.06	7.37 ± 0.07	0.757
PaCO ₂	42.75 ± 9.88	45.50 ± 21.62	0.668
PaO ₂	74.52 ± 34.47	49.75 ± 14	0.172
BE	1.26 ± 4.14	0.15 ± 8.26	0.588
HCO ₃	22.48 ± 5.18	25 ± 9.55	0.430

ANOVA test = analysis of variance; PaCO₂ = arterial carbon dioxide pressure; PaO₂ = arterial oxygen pressure; BE = basal excess; HCO₃ = bicarbonate; SG = successful group; UG = unsuccessful group

DISCUSSION

In our study, we observed that children who remained for longer lengths of time on IMV were those who were unsuccessfully weaned from ventilatory assistance. In the study of Farias et al. [14], the length of stay on IMV was greater in the group that was unsuccessfully weaned. Fontela et al. [15] studied children on IMV and reported that 10.5% required re-intubation within 48 hours after extubation; of these children, those that utilized IMV for more than 15 days suffered the highest extubation failure rate. When IMV was prolonged, the child remained in the ICU for a longer time, but, on the other hand, if weaning was premature, the risk of extubation failure increased considerably [6,16-19].

The SpO₂ presented a significant difference with a mean of 93.44% ± 8.03% in the SG and 70.0% ± 15.05% in the UG (P = 0.004). This finding supports the results of a previous study that demonstrated that children who remain longer on IMV and that have a lower SpO₂ generally are associated with failure of weaning [20].

The FiO₂ was significantly higher in the UG, with a mean of 34.72% ± 9.59% compared to the SG (52.75% ± 33.71% - P = 0.028). This data coincides with the study of Vasiliki et al. [7] who studied 30 premature children submitted to IMV whose weaning was carried out with a FiO₂ of less than 40%; failure of weaning was related to higher levels of FiO₂.

In this study weaning from IMV was successful (patients who remained 48 hours or more without the necessity of re-intubation) for 25 (86%) children. However, four (14%) children required re-intubation within 48 hours and were classified as unsuccessfully weaned.

Previous studies have shown that children can be successfully weaned from IMV, breathing spontaneously

during two hours. Nevertheless, there is a failure rate of 15% of children who are unsuccessfully weaned [20-23]. Recently it was demonstrated that extubation failure, with consequent re-intubation within 48 hours, is associated with a higher mortality rate compared to successful weaning [17,23,24].

In this study, statistical differences were not identified in the time of CPB, different to the study of Nozawa et al. [8], who studied 45 children with congenital heart diseases, with 22 on CPB for more than 120 minutes; of these 15 (68%) evolved with extubation failure. In this current study, the SG (86%) presented with a mean CPB time of 56.8 ± 47.57 minutes while the UG (14%) presented with a mean of 29.37 ± 57.09 minutes (P = 0.305). Previous studies have shown that prolonged CPB (greater than 120 minutes) is generally associated with a high risk of failure in weaning from IMV [18,23,25].

In the analysis of variables of patients who present with cyanotic heart diseases and of the patients with acyanotic heart diseases, there were no significant differences in respect to the success of failure of weaning from IMV. One hypothesis for this finding may be that the number of patients studied in this sample was insufficient to demonstrate any statistical difference.

We did not observe statistical differences in the weight of the patients between the two groups. A study by Myague et al. [5], of patients with congenital heart diseases, demonstrated that the age and the weight are significantly lower in children with congenital heart diseases when compared to healthy children.

In our study, the type of anesthesia utilized was general anesthesia in all patients including four children with Down syndrome; no complications due to the type of anesthesia were reported in these patients, different to the study of Edmunds et al. [25], that demonstrated that children with congenital heart diseases are more susceptible to develop complications with anesthesia, in particular those with Down syndrome.

The parameters of gasometry did not show statistical differences in our study. Vasiliki et al. [7] studied premature children submitted to IMV and, if after extubation they presented with respiratory acidosis (pH < 7.2) or peaks of apnea, they were re-intubated and weaning was considered unsuccessful. Bouso [23] confirmed, in his studies, that acidosis was associated with failure of weaning.

Our study presents limitations, including: losses during data collection as three patients died due to renal failure and cardiopulmonary arrest; the gestational age was not registered or analyzed, a factor that may be associated with failure of weaning, and the patients utilized two different models of mechanical ventilators and oximeters to control the peripheral saturation.

The incapacity to sustain spontaneous respiration after

extubation has been one of the main factors of failure in extubation [10,21-24]. The inexistence of validated extubation protocols adequate for children undergoing correction surgery of congenital heart diseases collaborates with the increase in failure rates during weaning of these patients [18,21-23].

CONCLUSION

This ongoing study demonstrated that the length of stay on invasive mechanical ventilation, the saturation of reduced peripheral oxygen and elevated levels of the inspired oxygen fraction are associated to unsuccessful weaning in children submitted to heart surgery, and so these three factors should be monitored during the weaning process from invasive mechanical ventilation.

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